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GLAST LAT SYSTEM SPECIFICATION	Subsystem/Office Calorimeter Subsystem	
Document Title **Specification for the CAL Flight Dual PIN Photodiode**		

Gamma-ray Large Area Space Telescope (GLAST)
Large Area Telescope (LAT)
Specification for the Calorimeter (CAL)
Flight Dual PIN Photodiode S8576-01

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes	DCN #
03	28 July 2002	Incorporate changes and agreements from 18 July 2002 meeting in Paris	
04	29 Aug 2002	Incorporate responses from Hamamatsu to Rev 03	
05	5 Sept. 2002	Incorporate changes required by CEA and clarification from Hamamatsu to Rev 04	
06	25 Sept. 2002	Incorporate changes discussed with CEA and Hamamatsu in 16 – 19 Sept meetings	
07	07 Oct. 2002	Incorporate changes from CEA	
08	11 Nov 2002	Incorporate changes from Hamamatsu and change from optical epoxy to optical silicone	
09/10	26 Dec 2002	Incorporate changes from CEA	
11	30 Jan. 2003	Incorporated changes fron NRL, CEA, and Hamamatsu	
11a	25 Feb. 2003	Incorporate changes from Hamamatsu and agreements by CEA	

Table of Contents

1 PURPOSE

This document specifies the mechanical, optical and electrical characteristics of the PIN photodiode assembly for the Calorimeter (CAL) subsystem of the GLAST Large Area Telescope (LAT). This assembly consists of a ceramic substrate containing two Silicon photodiode dies and is named Dual PIN Photodiode (DPD). The optical window of the DPD is encapsulated with NASA approved optical silicone resin.

2 SCOPE

This specification establishes the requirement for flight DPDs to be used in the Calorimeter subsystem of GLAST LAT. A total of 4500 DPDs are required for the flight instrument and spares.

All flight DPDs shall be inspected, screened, and qualified as per the requirement established herein. Hamamatsu process controls and manufacturing methods for the flight DPDs will be evaluated as per Appendix A, prior to finalization of flight procurement. The details of the material, manufacturing, quality controls, screening, and qualification for the flight procurement are defined herein.

3 DEFINITIONS

3.1 Acronyms

CAL	The Calorimeter subsystem of the LAT
CEA	Commissariat à l'Energie Atomique
CSAM	C-mode Scanning Acoustic Microscopy
CsI (Tl)	Cesium Iodide (Thallium doped) crystal
DPD	Dual PIN Photodiode
EM	Engineering Model
FM	Flight Model
GLAST	Gamma-ray Large Area Space Telescope
GSFC	Goddard Space Flight Center, NASA
LAT	Large Area Telescope
NASA	National Aeronautics and Space Administration
NCR	Non Conformance Report
LAT	Lot Acceptance Tests
MIP	Mandatory Inspection Points

FIT	Failure In Time
PAM	Product Assurance Manager
SEM	Scanning Electron Microscope
S/N	Serial Number
RFW	Request For Waiver
DPA	Destructive Physical Analysis
TBR	To Be Resolved
TBC	To Be Confirmed

3.2 Definitions

γ	Gamma Ray
µsec, µs	microsecond, 10^{-6} second
nm	Nanometer
µm	Micrometer
mm	Millimeter
cm	Centimeter
hPa	HectoPascal
°C	Degree Celsius
eV	Electron Volt
MeV	Million Electron Volts, 10^{6} eV
Ph	Photons
Gohm	10^{9} Ohm
Mohm	10^{6} Ohm
Kohm,	10^{3} Ohm
Degolding	Removal of gold-plating from the DPD leads in a separate solder bath before tinning in a separate solder bath.
Tinning	The coating of a surface of DPD leads with a uniform layer of solder before it is used in a soldered connection.

4 APPLICABLE DOCUMENTS

The following standards form a part of this document to the extent specified herein. Unless otherwise specified, the issue of these documents is those listed in the current issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereof.

Standards

ANSI/J-STD-002	Solderability Tests for Component Leads, Terminations, Lugs, Terminals, and Wires
NASA-STD-8739.3	Soldered Electrical Connections
MIL-STD-750	Test Methods for Semiconductor Devices
MIL-STD-883	Test Methods and Procedures for Microcircuits
311-INST-001	GSFC Instructions for Electrical, Electronic, and Electromechanical (EEE) Parts Selection, Screening, and Qualification
ECSS-Q-70-08A	Manual Soldering of High Reliability Electrical Connections
EIA-625	Requirements for Handling Electronic Discharge Sensitive Devices (ESDs)
LAT-MD-00099-03	GLAST LAT Electrical, Electronic, and Electromechanical Parts Program Control Plan
ISO 9001	International Organization for Standardization Quality Management Systems Requirements

5 INTRODUCTION

The GLAST mission is a NASA gamma-ray mission to be launched in 2006. The expected mission lifetime is greater than 5 years up to 10 years. The Large Area Telescope (LAT) instrument is the primary experiment on GLAST and consists of an anticoincidence device, a silicon-strip detector tracker, a CsI calorimeter (CAL), and a Trigger and Dataflow system. The principal purpose of the LAT is to measure the incidence direction, energy and time of cosmic gamma rays. The measurements are streamed to the spacecraft for data storage and subsequent transmittal to ground-based analysis centers. Section 7 of this specification, defines the environments to which the DPDs will be exposed to after assembly with CsI crystals.

The LAT calorimeter is a hodoscopic array of CsI(Tl) scintillation crystals. Scintillation light is collected by PIN photodiodes and processed by charge sensitive preamps. The CAL subsystem consists of a 4 $\times$ 4 array of identical modules. Each module is a hodoscopic array of 96 CsI scintillation crystals and associated readout electronics. Each crystal is approximately 27 $\times$ 20 $\times$ 326 mm in size with a DPD attached on each end.

One DPD (consisting of one large and one small photodiode die), is required at each end of the crystal to support the electronic measurements over the required dynamic range of the energy depositions. The DPD shall be bonded to the CsI crystal using a NASA approved optical silicone adhesive. This specification defines the mechanical, optical and electrical characteristics of DPD consisting of a ceramic substrate, two photodiode dies (one large and one small), wirebonds, and optical silicone resin used for encapsulation.

DPDs procured to this specification will be manufactured and assembled using controlled processes. DPD assembly involves two photodiode dies (one large and one small), attached to a ceramic substrate by silver filled epoxy, gold wirebonds, and encapsulating of the assembly using optical silicone resin. Each DPD has 4 tinned leads (Anodes and Cathodes of each diode) for external electrical connections.

6 Requirements of the Photodiode Dies, Ceramic Substrate, Optical Silicone Resin, Assembly Lot Qualification And Screening

6.1 Requirements on the DPD

6.1.1 Heritage of the DPD

This specification is based on the previous GLAST DPD development at Hamamatsu Photonics, part number S3590 SPL 2CH which was developed for the Naval Research Laboratory in 1998 and the last development for NRL and CEA in 2001, part number S8576. The Hamamatsu for the S3590 SPL 2CH part is K03-B70065, dated 6 August 1998, and for the S8576 is K03-B72019 Rev A, dated 23 November 2001. The DPDs encapsulated with optical silicone resin as specified herein are referred by part number S8576-01. The characteristics specified in Tables 1 and 2 for the S8576-01 are based on the Hamamatsu S8576 design characteristics and delivery specification sheet KQC-B14514 preliminarily dated ~~January 28th~~February 20th ~~-~~2003.

6.1.2 DPD electrical and optical specification

6.1.2.1 Diode A

The smaller of the two photodiode dies in the ceramic carrier shall be designated as Diode A and shall have an active area of 10.5 × 2.4 mm as defined in figure 1. Table 1 specifies the electrical and optical characteristics of Diode A at +25 °C.

Table 1. Electrical and Optical Properties of PIN Diode A (small diode) at 25 °C ± 1°C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Active Area	–	–	- 1%	25.2	+ 1%	mm^2
Active Area Size	–	–		10.5x2.4		mm
Spectral Response Range	λ	–	–	320 ~ 1100		nm
Peak Wavelength	λp	–	–	960	–	nm
Photo Sensitivity	S	λ = 540 nm	0.35	0.38	0.41	A/W
Dark Current	I_D	V_R = 70V	0.2	1.0	3.0	nA
Terminal Capacitance	C_t	V_R = 70V f = 1 MHz	12	14	16	pF

Cut-off Frequency	f_C	V_R = 70V, λ=830nm, R_L=50Ω, -3DB	–	45	–	MHz
Reverse Voltage	V_R			70	100	V

6.1.2.2 Diode B

The larger of the two photodiode dies in the carrier shall be designated as Diode B and shall have an active area of 10.5 × 14.0 mm as defined in figure 1. Table 2 specifies the electrical and optical characteristics of Diode B at 25 °C.

Table 2. Electrical and Optical Properties of PIN Diode B (large PIN) at 25 °C ± 1°C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Active Area	–	–	- 1%	147.0	+ 1%	mm^2
Active Area Size	–	–		10.5 × 14.0		mm
Spectral Response Range	λ	–	–	320 ~ 1100	–	nm
Peak Wavelength	λp	–	–	960	–	nm
Photo Sensitivity	S	λ = 540 nm	0.35	0.38	0.41	A/W
Dark Current	I_D	V_R = 70V	0.5	2.5	7.5	nA
Terminal Capacitance	C_t	V_R = 70V f = 1 MHz	54	63	72	pF
Cut-off Frequency	f_C	V_R = 70V, λ=830nm, R_L=50Ω, -3DB	–	35	–	MHz
Reverse Voltage	V_R			70	100	V

6.1.3 DPD Wire Bond Connection

Diodes A & B are connected by ~~25~~ 30 micrometer diameter gold wires to ceramic substrates. There are a total of 4 wirebond connections, two (one redundant wirebond connection) on each die. The design of the wirebond pads on the photodiode dies and wirebond strength verification will be done in accordance with MIL-STD-883, methods 2010 and 2011.

6.2 Requirements on the Ceramic Substrate

6.2.1 Mechanical specification

Mechanical specifications are defined in figure 1 and ceramic material will be as per Hamamatsu's heritage part number S8576, which has been evaluated for flight application and has flight heritage. A new generic part number assigned to this DPD encapsulated, with optical silicone resin by Hamamatsu is S8576-01.

6.2.2 Lead Electrical Connections

The ceramic substrate shall provide isolated connections as per 6.4.11.2.2 to the individual diode cathodes and anodes through four (4) brazed iron-nickel alloy (Fe; 58%, Ni; 42%) kovar leads with nickel and gold plating prior to tinning, as defined in figure 1.

6.3 Requirements for the DPD manufacturing

6.3.1 Photodiode Die Attach

6.3.1.1 Die Attach Process

Photodiode die attach, the process by which the tested photodiode dies are attached to the flight qualified ceramic substrate. The die attach process is performed in the assembly after cleaning of the tinned leads and tested substrate as defined herein.

The die attach process control can be broken down into three steps:

1. Dispensing of the adhesive
2. Alignment and placement of the die
3. Curing of the adhesive

In the first step, the die attach adhesive is dispensed in a pre-calculated and verified amount, which ensures the proper bondline (thickness of the cured adhesive under the die).

The second step of the process includes die alignment and placement. The die is acquired from its carrier and properly oriented. The die is placed onto the adhesive and set in place producing a visible attachment of material around the edge of the die. During the die attach, process controls shall meet as specified in table 3. Many die bond problems such as low bondline, edge voids, undercutting, material on die, over filleting (Table 4 for a complete reference list), are traceable to lack control in the die alignment and dispensing of the adhesive.

Table 3. Parameters to be used for Defining Die Attach Process and Process Controls

DIE ATTACH PROCESS AND CONTROL PARAMETERS
STEP 1: Dispense Adhesive
Dispense quantity and repeatability Pattern uniformity and repeatability Rheology Pot Life Bondline thickness – before and after cure Bleedout
STEP 2: Alignment and Placement of Die
Six degrees of freedom placement accuracy Repeatability
STEP 3: Cure of Adhesive
Time-temperature sensitivity Humidity Shrinkage Post bonding thermal and mechanical testing

Table 4. Parameters Associated with Die Bonding Problems (For Reference)

DIE BONDING PROCESS PROBLEMS					
	Dispense	**Place**	**Ceramic Package Handling**	**Cure**	**Rework**
Low Bondline	X	X			
Edge Voids	X	X			
Undercutting	X	X			
Material on Die	X	X		X	
Overfilling	X	X			
Flaking	X				
Bridging	X				
Cracking			X	X	
Disbanding			X	X	
Bleedout				X	X
Misorientation Misalignment		X			
Die Chips/Scratch		X	X		

Curing of adhesives is usually the easiest to perform and control. It is necessary to control time, temperature, and environmental parameters such as humidity.

There will be a minimum clearance of 100 µm between the dies and the ceramic walls and photodiode dies are attached to ceramic substrate with silver filled epoxy resin. This will be verified during visual inspection prior to wirebonding at Hamamatsu.

6.3.1.2 Die Attachment Control and Issues

Delamination / voids in the die attach region is known to increase thermal resistance of that interface, leading to increased die temperature, stresses and reduced reliability. The effects of the die attach region delamination/void, especially on corners; can have a significant effect on the encapsulated silicone resin, hence the die attachment process should be controlled at Hamamatsu.

6.3.2 Silicon Photodiode Mounting, Insulation, and Silicone resin Encapsulation

6.3.2.1 Photodiode Mounting

The two photodiodes shall be mounted in such a manner to preserve electrical insulation. The electrical and optical characteristics of the two photodiodes are addressed in Tables 1 and 2.

6.3.2.2 DPD Encapsulation/Filling

The two photodiode dies attached to the ceramic substrate shall be encapsulated with a NASA/GSFC approved optical Shin-Etsu KJR-9022~~E~~ silicone resin to protect wire bonds and sensitive surfaces of dies. The Shin-Etsu KJR9022~~E~~ material was approved by GSFC for outgassing for space application after baking at 175°C at one atmosphere or in a vacuum for 24 hours. All DPDs after encapsulation and curing shall be baked at 175°C for 24 hours prior to shipping. Any change in the silicone resin material shall be approved by NRL/CEA prior to its use.

6.3.2.2.1 Shin-Etsu KJR9022~~E~~ Optical Silicone Resin

The cured optical silicone resin shall be capable of enduring temperatures of -30°C to +50°C, humidity, mechanical shock, thermal cycle, thermal vacuum, and must be able to adhere to the substrate, bondwire and die without affecting the performance as specified herein. Optical silicone resin shall also meet the optical and electrical requirements as specified herein. The silicone resin shall be cured and handled as per the Shin-Etsu KJR9022~~E~~ silicone resin manufacturer's specification. The optical silicone resin shall have excellent optical clarity, wicking and wetting characteristics. Procedures used for silicone resin storage, encapsulation, curing and baking shall be controlled using written procedures. Maximum concavity after the silicone resin curing and baking in the DPD cavity shall not exceed 150 microns (TBD) and as a minimum, the optical silicone resin shall cover all wire bonds. The silicon resin is assumed to be concave and any bubbles greater than or equal to 200 µm in diameter shall be rejected.

6.3.2.2.2 Optical Surface and Alignment

The photodiode assembly shall be encapsulated using the NASA/GSFC approved Shin-Etsu KJR9022~~E~~ silicone resin and shall meet the dimensions as specified in figure 1 after encapsulation.

6.3.3 Manufacturing flow charts

Detailed manufacturing and Quality Control (QC) flow charts shall be prepared for the ceramic substrate, lead tinning, DPD assembly and shall be available for review at Hamamatsu. These flow charts shall provide evidence of various inspection points during manufacturing and testing, with reference to the relevant procedures. These flowcharts will be available for review shall be translated into English. Contractual mandatory inspection points will be selected by mutual agreement of Hamamatsu and NRL/CEA during the kick-off meeting prior to any flight and qualification parts production.

6.3.4 General Cleanliness and Packaging Precautions

The manufacturing, testing and packaging of the DPD prior to shipment, shall be Hamamatsu's responsibility. The DPD will be packed and shipped as per Appendix B. DPDs will be packed in a clean environment free of dust and free of contamination, according to Hamamatsu internal contamination plan. The contamination control plan, cleaning procedures, and packaging details shall be made available for review at Hamamatsu.

6.3.5 Suggested Cleaning Methods to Improve Bondability of Wirebond, Adhesion of Optical Silicone Resin to Ceramic Substrate, Die, and Wirebonds

Various cleaning methods shall be used to remove contaminants at different stages of wafer processing, ceramic substrate, die attachment, wirebonding, and prior to silicone resin encapsulation without damaging the die passivation. Die passivation thickness can be damaged by use of cleaning chemicals and can affect the long-term optical performance of the DPD. Care should be taken to verify the compatibility of cleaning material with the die passivation. Bond pad metallizations often contain various additives and are reactive to ion processing of the wafer, which can leave fluorocarbon films on the surface. All of these can inhibit the wire bondability and can affect reliability. Because of the extensive handling, as well as the use of silver die attach, the suitable cleaning methods should be adopted prior to silicone resin encapsulation. ~~Selected cleaning methods shall be discussed during the kick-off meeting at Hamamatsu~~Solvent, plasma cleaning, and vacuum bakeout 200°C will be performed prior to die attachment in the cavity of the ceramic substrate.

6.3.6 Molecular Cleaning Methods

Atmosphere impurities resulting from the long storage of dies combined with a great deal of handling and processing leads to contamination, which requires cleaning. The combination of Freon and cold deionized water cleaning is recommended. However, Hamamatsu can adopt any other method for cleaning the substrate, dies, and wirebond pads, which ensures reliability of the DPD to this specification~~ agreeable to NRL/CEA during the kick-off meeting~~. Hamamatsu will use solvent, plasma cleaning, and vacuum bakeout at 200°C.

6.3.7 Storage Before Silicone Resin Encapsulation

Once an assembly has been cleaned, it can become recontaminated if the DPDs are not stored in a controlled storage environment prior to silicone resin encapsulation. Hamamatsu shall store these assemblies in a strictly controlled environment.

6.3.8 Hamamatsu's In-Process Controls

Hamamatsu shall define nature and frequency of in-process inspection points on manufacturing flow charts and must be available for review during the kick-off meeting at Hamamatsu. The Product Assurance Manager of Hamamatsu shall monitor all the manufacturing processes and shall perform inspections as specified in the Hamamatsu procedures and in this specification.

Mandatory Inspection Points (MIP) will be identified during the visit to Hamamatsu by NRL/CEA. NRL/CEA reserve the right to inspect the DPD at those selected MIPs. MIPs shall not interfere the production process at Hamamatsu. Coordination of a visit to Hamamatsu for MIPs shall be planned by mutual concurrence to avoid production delays. Hamamatsu shall maintain the traceability and list of GSE used during assembly and testing of DPDs.

6.4 Product Assurance Requirements

Delivered DPDs shall be those that have been subjected to and passed the requirements, tests, and inspections detailed herein.

6.4.1 Hamamatsu's Capability

Hamamatsu's capability to comply with the requirements of this document and QA assessment as per Appendix A shall be verified during visit to Hamamatsu. Exceptions taken by Hamamatsu to the design rules and process control requirements shall be reviewed and considered for acceptability prior to finalization of the order.

(***NOTE***: Hamamatsu response to QA assessment as per Appendix A was received and shall be reviewed and reverified during the visit to Hamamatsu.)

6.4.2 Capability Assessment

A capability assessment shall be performed to verify that the manufacturer's quality management program achieves a level of quality level of ISO9001 and that Hamamatsu has and uses production facilities, test facilities and a verification program, which is capable of meeting the requirements of this specification.

6.4.3 Design and Construction

These design and construction rules should be consistent with Hamamatsu's internal specifications and shall be available for review. Hamamatsu shall document all exceptions taken to the requirements and shall justify how the exceptions are implemented without compromising the overall reliability and performance of the DPD. This documentation shall be available for review during the visit to Hamamatsu. Designs shall be capable of passing all tests specified herein.

6.4.4 Control Procedures

Hamamatsu shall have a system, which shall include procedures for notification of changes that affects form, fit, function, and change in the processes. The following processes and procedures shall not be changed after qualification, without approval from NRL/CEA:

a. Design methodology changes

b. Photodiode die fabrication process changes

c. Ceramic substrate changes

d. Assembly process changes

e. Silicone resin mix, filling, curing records and control procedures

f. Test facility and testing methods changes

g. Lead tinning process changes

6.4.5 Materials

Materials used in the assembly of DPD shall meet the following:

a. Optical silicone resin shall meet NASA/ESA outgassing and must be evaluated for reliability and performance requirements of a maximum total mass loss (TML) of 1.0% and a maximum collected volatile condensable materials (CVCM) of 0.10%. Shin-Etsu KJR9022E optical silicone resin was approved by NASA/GSFC for outgassing after baking at 175°C for 24 hours at one atmosphere.

b. The cure temperature of optical silicone resin shall be controlled and shall not cause undue stress on the optimal performance of DPD under temperature excursions.

c. Materials shall be selected such that thermal expansion rate mismatches between different materials (i.e., die, ceramic, silver epoxy, wirebond, optical silicone resin) do not compromise integrity, reliability and performance during temperature excursions as specified herein.

d. Coatings including markings shall be non-nutrient to fungus and shall not blister, crack, flow, or exhibit defects that adversely affect storage, operation, or environmental capabilities of the DPD.

e. A list of material to be used for the manufacturing of the DPD shall be maintained at Hamamatsu and shall be available for review except for proprietary material. Materials not approved by NASA or ESA shall not be used.

6.4.6 Lead Tinning Process

Pure tin is prohibited as a finish on the leads and as an undercoat. Tinning of gold plated leads shall be performed on the blank ceramic substrates prior to assembly of dies and wirebonding. Tinning shall extend the entire length of the electrical pin to within 0.3 mm of the ceramic carrier.

Gold shall be removed from DPD leads by dipping the leads into a solder (~~63% Sn, 37% Pb~~ lead free Sn96Ag3.5 or equivalent) bath twice, (bath 1) held at 250ºC to 280ºC for 2 – 3 seconds. After gold dissolution the leads shall be pre-tinned (in bath 2). During this process regular analyses of baths 1 and 2 shall be made. Alternatively the solder within these baths may be regularly replaced, (the replacing frequency shall be justified). The gold shall not exceed 1 % by weight in bath 1. Bath 2 shall not be contaminated with copper in excess of 0,25 % by weight or gold in excess of 0,2 %, the total gold plus copper not exceeding 0,3 %. Contamination with zinc, aluminum or iron shall be carefully avoided. When the solder produces a dull, frosty or granular appearance on the lead, the bath shall be removed from use.

The solderability of the leads shall meet ANSI/J-STD-002 requirements. For additional details on the lead tinning process, refer to the NASA soldering specification, NASA-STD-8739.3, and ESA soldering standard, ECSS-Q-70-08A. Hamamatsu ~~would like to use SN 63%, Ag 2%, and Pb 35% solder. NRL does not have a problem with that, but CEA to confirm~~will use M30 high temperature lead free solder SN96Ag3.5, from Senju Metal Industry Company, to avoid reflow during vacuum bakeout operation at 200°C.

6.4.6.1 Prerequisites

Each Hamamatsu tinning contractor is responsible for maintaining a documented tinning program, which meets the requirements of this specification. The program may involve procedures for training, certification, maintenance of certified status, recertification and revocation of certified status for tinning and inspection personnel.

Records shall be kept to provide identification between the finished product and the operator. Records shall also be maintained of the training, testing and certification status of tinning operators. Equipment and tools shall be verified or calibrated periodically for proper operation, and records of calibration shall be maintained.

6.4.6.2 Facility Cleanliness

Unless this tinning facility is classified as a clean room, the areas in which tinning are to be carried out shall be maintained in a neat orderly fashion with no loose material (such as dirt, dust, solder particles, oils, clipped wires) that can cause contamination.

Working surfaces shall be covered with an easily cleaned hard top or have a replaceable surface of clean, non-corrosive silicone-free paper. Tools and fixtures to be used in the tinning operation shall be clean; excess lubricants shall be removed before tinning starts. Before tinning, the leads shall be visually examined for cleanliness, absence of oil films and freedom from tarnish or corrosion.

6.4.6.3 Environmental Conditions

The tinning area shall have a controlled environment, which limits entry of contamination. The following environmental conditions in the area shall be continuously maintained:

- room temperature: (22 ± 3) ºC;
- relative humidity at room temperature: (55 ± 10) %.

The work stations shall not be exposed to draught. Fresh air shall be supplied to the room through a filtering system and, so that there is a positive pressure difference with respect to adjacent rooms, the exhaust air shall be suitably restricted.

6.4.7 Thermal Design

DPD's do not produce any internal heat, therefore operating case temperature is the same as the case temperature. Operating temperature range is -40° to +70°C.

6.4.8 Process Controls

Hamamatsu shall implement a methodology to detect defective processes prior to completion of flight DPD assembly. Hamamatsu shall document all exceptions taken to the requirements and shall justify how the exceptions are implemented without compromising the overall reliability and performance of the manufactured product. Following are the example of process controls to be used for each process.

1) Wire Bonding Process Evaluation - A process machine/operator evaluation shall be performed:

    a. When a machine is put into operation.

    b. Periodically while in operation, not to exceed 4 hours.

    c. When the operator is changed. Change of certified auto wire bond operators is allowed without machine reevaluation if all other machine conditions for evaluation are maintained.

d. When any machine part has been changed.

e. When any machine adjustment of the process parameters has been made.

f. When the spool of wire is changed.

g. When a new device type is started

2) Process Machine/Operator Evaluation - Sample wires from three devices or a test sample shall be destructively pull tested in accordance with MTIL-STD-883, method 2011 and as follows:

   a. A minimum of 10 wires total, consisting of wire bonds to die metallization-bonding systems typical of DPD assembly operation shall be tested.

   b. If any of the sample wires fail, the machine/operator shall be deactivated and corrective action taken. When a new sample has been prepared, tested, and has passed this procedure, the machine/operator has been certified or recertified, it can be returned to service.

3) A list of qualified processes to be used for the manufacturing of the DPD shall be available for review to NRL/CEA at Hamamatsu. Hamamatsu shall be responsible for qualification of all processes used during manufacturing of DPD, assembly, testing, packaging, storage, and shipping of DPDs.

6.4.9 Traceability

Traceability for each DPD and its constituent materials shall be as follows.

a. All DPDs manufactured shall be traceable within Hamamatsu systems from purchase order review to shipment. Every manufacturing lot for wafer fabrication, substrate fabrication and DPD assembly shall have a unique number that is traceable from the raw material stage through every step in the manufacturing process. It is preferable to manufacture each die type from a single and similar wafer lot and substrates from a single and similar material lot and processes. The same lot number with a suffix or equivalent internal standard shall be used to identify all sub-lots of the original manufacturing lot. Once a manufacturing and assembly lot has been defined, only sub-lots of the same manufacturing lot can be combined into a single lot. Every lot is documented by electronic and paper travelers that record the processing date, measured values, the machine identification and the revision of the test program along with the batch of raw materials that was used at each manufacturing step. DPDs identity shall be inherently obvious through all manufacturing steps. Individual die will not have any product identity marking. Maintenance of DPDs identity and traceability in the assembly process shall be assured by Hamamatsu assembly procedures. After assembly, DPD identification shall be again inherent with a date code and S/N that is uniquely associated with the Hamamatsu manufacturing lot number.

b. Traceability will be such that for each DPD, die attachment, ceramic substrate, tinning, adhesive, and optical silicone resin will be traceable to a material production lot, inspection lot, or other specified grouping. All photodiode dies, tinned lead ceramic substrates, and materials used will be traceable to their incoming inspection lots. Records will be maintained to provide traceability from the DPD serial number to the specific wafer lot from which each die originated.

c. Each DPD, or each group of DPDs which have been fabricated as a lot, will be identifiable through means of production travelers or similar documentation such that the complete manufacturing history, including rework, will be recorded. The records should include, as a minimum, the performance date of all identified production process steps, the specification, number of production process steps, and the identification of the operator performing the process steps.

d. Records should identify when each production or inspection lot was processed through each area. These records should identify, for each production or performance verification lot (as applicable) of finished DPD, test/inspections performed and results, DPD serial numbers, date of completion, lot identification.

e. Hamamatsu should define all processes and methods used to assure the capability and consistency of the processes.

f. Records should cover the implementation of tools such as control charts or other means of indication of the degree of control achieved at the points in the material, and assembly process flow documented in the manufacturing instructions. Records should also indicate the action taken when each out-of-control condition is observed, and the disposition of product processed during the period of out-of-control operation.

g. Design and Manufacturing Documentation - In addition to documentation required as part of the purchased ceramic substrate, design, topography, schematic circuit information, manufacturing flowcharts, and process control documents for all DPDs shall be maintained by Hamamatsu for a period of 5 years and shall be available for review.

h. Laser markings on the backside of the ceramic substrate shall include Photodiode type, assembly production date code (lot #) and serial number at a location as defined in figure 1.

6.4.10 Definition of Lot and Testing Related to the Lot

6.4.10.1 Definition of Wafer Lots

Wafer lots consist of photodiode die wafers formed into lots at the start of wafer fabrication for homogeneous processing as a group. Each lot is assigned a unique identifier or code to provide traceability and maintain lot integrity throughout the fabrication process. Wafer lot processing as a homogeneous group is accomplished by any of the following procedures, providing process schedules and controls are sufficiently maintained to assure identical processing in accordance with process instructions of all wafers in the lot. Extended periods between sub-lots allowed, which meets the criteria of procedure and processes as defined herein.

a. Batch processing of all wafers in the wafer lot through the same machine process steps simultaneously.

b. Continuous or sequential processing (wafer by wafer or batch portions of wafer lot) of all wafers through the same machine or process steps.

c. Parallel processing of portions of the wafer lot through multiple machines or process stations on the same certified line, provided statistical quality control (SQC) assures and demonstrates correlation between stations and separately processed portions of the wafer lot.

Wafer lots not meeting the above requirements will be considered as a separate lot. Each lot will require qualification as indicated in the Lot Acceptance Qualification Test of table 5B.

At the kick-off meeting, Hamamatsu shall define the number of wafer lots to be used for production requirements of this specification not meeting the above wafer lot definition.

6.4.10.2 Definition of Ceramic Substrate Lots

6.4.10.2.1 Ceramic Lot Prior to Tinning

Prior to tinning, ceramic substrate lots consist of ceramic substrates formed into lots at the start of the substrate fabrication for homogeneous processing as a group. Substrate lot involves the use of homogeneous alumina material having the same number of layers, design, manufacturer using the same facilities, processes, materials, printed, plating, and using the same controlled documented processes and approved procedures.

Ceramic substrate lot processing as a homogeneous group is accomplished by any of the following procedures, providing process schedules and controls are sufficiently maintained to assure identical processing in accordance with process instructions of all substrates in the lot. Extended periods between sub-lots allowed, which meets the criteria of procedure and processes as defined herein.

a. Batch processing of all substrates in the substrate lot through the same machine process steps simultaneously.

b. Continuous or sequential processing (substrate by substrate or batch portions of substrate lot) of all substrates through the same machine or process steps.

c. Parallel processing of portions of the substrate lot through multiple machines or process stations on the same certified line, provided statistical quality control (SQC) assures and demonstrates correlation between stations and separately processed portions of the substrate lot.

Ceramic substrate lots not meeting the above requirements will be considered as a separate lot. Each lot will require qualification as indicated in the Lot Acceptance Qualification Test of tables 6A-2, and 6B.

6.4.10.2.2 Ceramic Lot After Tinning

After tinning, ceramic substrate lots consist of ceramic substrates inspected and tested as defined in 6.4.10.2.1 and tinned as per 6.4.6. This substrate lot involves the use of controlled materials and processes, using the same facilities and trained operators for tinning using controlled documented approved processes and procedures as defined herein.

This substrate lot processing as a homogeneous group is accomplished by providing process, procedures, schedules, and controls that are sufficiently maintained to assure identical processing in accordance with process instructions of all substrates in the lot. Ceramic substrate lots after tinning not meeting the above requirements will be considered as a separate lot. Each lot will require qualification as indicated in the Lot Acceptance Qualification test of tables 6A-2 & 6B.

6.4.10.3 Assembly Lots

Assembly lots consist of DPDs that are compliant to this specification and capable of meeting qualification requirements of table 9 outlined herein. DPDs that are assembled on a manufacturing line which is controlled by Hamamatsu's quality management program and has been certified and qualified in accordance with the requirements herein.

Hamamatsu will not modify, substitute, or delete the tests and inspections defined herein or in Hamamatsu's procedures. No processes and procedures shall be changed after baselining of the flow of assembly processes, tests, and inspections which will assure that the DPDs are capable of meeting the verifications provided in this specification. This shall include the incoming inspection flow, the in-process inspection flow, the screening flow, and qualification flow. Extended periods between sub-lots allowed, which meets the criteria of procedure and processes as defined herein.

Adequacy of Hamamatsu to meet the requirement of this specification shall be determined by NRL/CEA in addition to Hamamatsu's internal controls. Any deletions or changes to procedures, materials, processes, or test flows shall be reviewed for risks imposed by those changes and may require re-qualification as indicated in the Lot Acceptance Qualification Test of table 9. Requalification, if required, shall be determined by NRL/CEA after evaluating the risks.

6.4.11 DPD Qualification Requirements

DPD qualification shall meet the criteria of Tables 5 through 9 and as described below. DPDs used for qualification shall be assembled using controlled processes. DPD test procedures shall be established by Hamamatsu and shall be available for review. A failure to meet the requirements of the following tables will lead to the rejection of flight lot from which the DPDs are selected. All quantities in the lot have to be reviewed depending on the DPD quantity manufactured in each lot as defined herein.

6.4.11.1 Photodiode (Large and Small) Die Qualification

100% die electrical evaluation at the wafer level for measurement of dark current will be performed by Hamamatsu as per table 5A. After the dies are cut, sorted, and 100% visually inspected, 5 samples from each wafer lot will be shipped to CEA for SEM evaluation as per table 5B. The results of the tests will be sent to NRL and Hamamatsu within one month of receipt of samples. The written report of tests will be available within one month (TBC).

Table 5A. Wafer level die evaluation and visual requirements after cutting and sorting (To be performed at Hamamatsu)

S / N	Test	Method	Condition	Quantity
1	Die Electrical at wafer level	Hamamatsu's internal procedure	Dark current measurement as per table 8A and 8B	100%
2	Die Visual after cutting and sorting	2072	MIL-STD-750	100%

Table 5B. To be performed by CEA

S / N	Test	MIL-STD-883		Quantity
		Method	Condition	
1	SEM on dies supplied by Hamamatsu	2018	To be performed by CEA	5 samples per wafer lot

6.4.11.2 Ceramic Substrate Qualification

Hamamatsu shall obtain qualification and screening data for the ceramic substrates from their supplier. This data shall be available for review at Hamamatsu. Ceramic substrate received from their subcontractor shall meet the criteria as specified in Table 6A-1 by Hamamatsu. A ceramic substrate inspection lot will consist of homogeneous alumina having the same number of layers, designs, manufactured using the same facilities, processes, materials printed and plated using controlled documents and approved processes. Parallel processing of portions of the ceramic substrate lot through multiple machines or process stations on the same certified line, provided Statistical Quality Control (SQC) assures and demonstrates relation between manufacturing stations and separately processed portions of the substrate lot shall be considered as the same lot. Ceramic substrates after lead tinning shall meet the criteria as specified in table 6A-2.

Testing as specified in table 6B, shall be performed by CEA on 1% of the lot, minimum of 9, on substrate screened as per table 6A-2. These tinned leaded substrates will be supplied by Hamamatsu to CEA for their qualification as per table 6B. Results of the tests will be sent to Hamamatsu and NRL within 7 days from receipt of the ceramic packages.

6.4.11.2.1 Physical Dimensions of Blank Substrate

Inspect as per figure 1 and Hamamatsu acquisition specification before and after lead tinning.

6.4.11.2.2 Electrical

Substrates will be electrically tested at +25°C before and after tinning for the following characteristics:

a. Leakage current at 100 volts (0.1nA).
b. Capacitance will be measured as specified in the Hamamatsu acquisition specification, test for dielectric withstanding voltage, insulation resistance, and dissipation factor on samples from each lot of blank ceramic packages only.
c. Continuity and isolation testing shall be performed to verify the interconnection of conductors as specified in the acquisition specification of Hamamatsu on the samples from each lot to verify the design integrity.

Substrates, which fail the criteria's of table 6A-1 and 6A-2, shall be identified, segregated, and removed. Ceramic substrate lots, which fail the criteria's of table 6B, shall be rejected.

Table 6A-1. Blank Ceramic Substrate Qualification Requirements for each lot by Hamamatsu or their supplier on blank ceramic packages.

S / N	Test	MIL-STD-883		Quantity
		Method	Condition	
1	Physical dimension before tinning		As per para. 6.4.11.2.1 ~~and verification of lead center position as per drawing using approved fixture (TBD)~~	1% randomly selected / lot
2	Electrical Testing		As per para. 6.4.11.2.2 (a) at 25°C As per para. 6.4.11.2.2 (b) at 25°C As per para. 6.4.11.2.2 (c) at 25°C	~~100% / lot~~ 5 pcs / shipping sub-lot 5 pcs / shipping sub-lot ~~10 / lot~~ 5 pcs / shipping sub-lot~~10 / lot~~
3	Visual inspection		As per para. 6.4.13	100% / lot

Table 6A-2. Blank Ceramic Substrate Qualification Requirements for each lot by Hamamatsu or their supplier on blank ceramic packages. (After Tinning)

S / N	Test	MIL-STD-883		Quantity
		Method	Condition	
1	Visual inspection after tinning		As per para. 6.4.13	100% / lot
2	Electrical Testing		As per para. 6.4.11.2.2 (a) at 25°C As per para. 6.4.11.2.2 (b) at 25°C As per para. 6.4.11.2.2 (c) at 25°C	100% / lot 10 / lot 10 / lot
3	Physical dimension after tinning		Only verification of lead center position as per drawing using approved fixture	1~~00~~% / lot

Table 6B. Blank Ceramic Substrate after Tinning Qualification by CEA (1%, minimum qty. 9)

S / N	Test	MIL-STD-883		Quantity
		Method	Condition	
1	Lead Integrity	2004	Lead fatigue, only on degolded lead blank substrates	3 / lot
2	Solderability	ANSI/J-STD-002	Tinned lead substrates	3 / lot
3	Radiography	2012.7	Tinned lead substrates	3 / lot
4	DPA	5009.1	Tinned lead substrates	2 / lot
5	Physical Dimension	2016	As per para. 6.4.11.2.1 and verification of lead center position as per drawing using approved fixture ~~(TBD)~~	100%

Results from tests as per table 6B will be sent to Hamamatsu and NRL within 7 days from receipt of blank ceramic substrates.

6.4.11.3 CEA Testing Philosophy

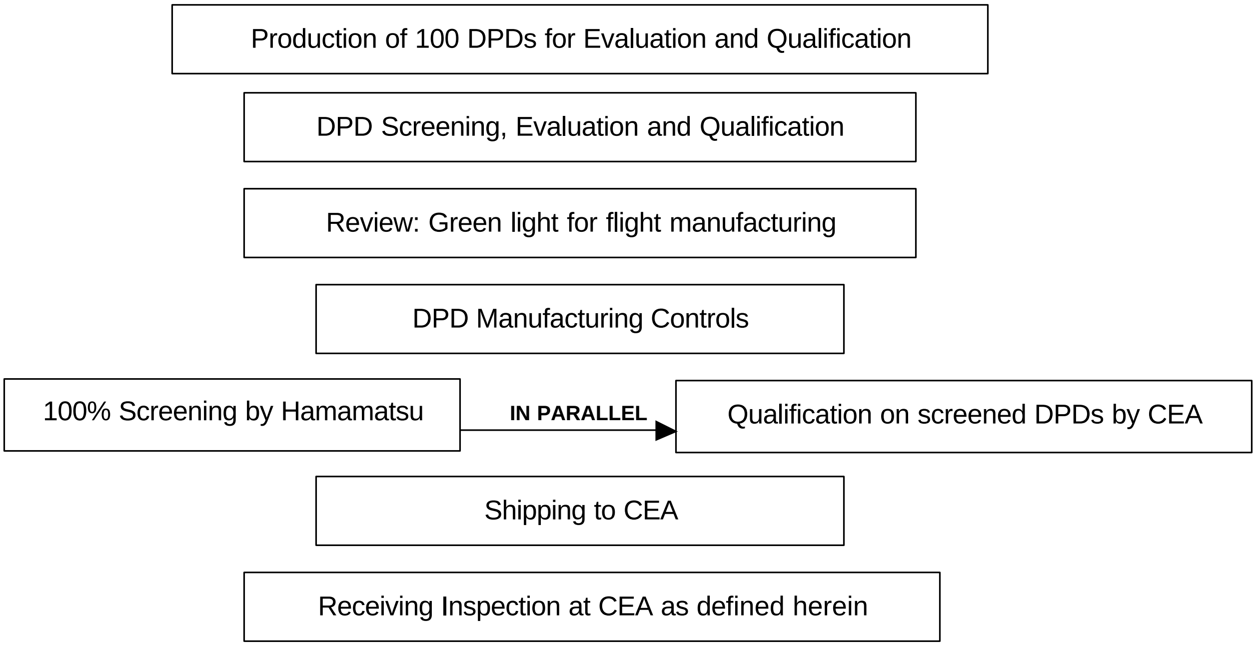
Technology evaluation will be performed on the first production samples to evaluate the functional limit of the DPDs. The technology evaluation involves the testing of the DPDs to 25% higher limits of the qualification levels as specified in the table 9. Technology evaluation will be performed by CEA for understanding the limits of the technology. DPDs, which meet the requirements of qualification levels as per table 9 could be considered acceptable even if it does not meet the 25% higher evaluation criteria of CEA and it depends on the parameter involved. This qualification and evaluation is only valid on one well-defined controlled and repeatable process (including processes, manpower, tooling, material, testing, etc). All DPDs used for technology evaluation and qualification shall meet the screening requirements as defined herein in table 7.

As a result of the time schedule and the technology evaluation already performed on the S8576, the qualification as per table 9 will be performed on 60 DPDs picked in the first delivery. This qualification will be performed in parallel to continuation of flight diode production. CEA will expedite the results of this testing to avoid any risks for the unknown changes suggested from this lot testing. We do not expect any issues out of this 60 piece qualification testing since this lot is manufactured using the same processes and control as was previous technological evaluation lot.

The screening of DPDs has been selected by NRL/CEA to remove infant mortality and to control the manufacturing processes. Hamamatsu will perform 100% screening tests as per table 7. Since measurements of the DPDs at CEA performed on the S8576 have shown good correlation with Hamamatsu's test data, only sampling tests will be performed to verify the reliability of Hamamatsu measurements and to verify potential degradation during the shipment (the sampling quantity less than 10% of the lot size).

Flight DPD Specification & Order

Kick-Off Meeting



6.4.11.4 DPD Screening

Screening, including burn-in, shall be performed by Hamamatsu on 100% of flight DPDs in accordance with Table 7. All DPDs shall meet electrical measurements taken during screening and shall be read and recorded. DPDs, which fail any screening tests, shall be identified, segregated, and removed.

Table 7. Screening

S / N	Test Inspection	MIL-STD-883		Quantity
		Method	Condition	
1	Baking at 175°C for 24 hours at one atmosphere	As specified herein		100% Lot
2	Visual Inspection after optical silicone resin encapsulation	As specified herein	As per para. 6.4.13	100% / Lot
3	Temperature cycling unpowered		-20°C to +45°C for 10 cycles. Ramp rate not to exceed 1°C/minute with ½ hour dwell at each temp.	100% / Lot
4	Electrical	As per defined herein	In accordance with tables 8A & 8B. Only dark current measurements required	100% / Lot
5	Burn-in with DPD biased at 70V	1015	168 hrs at +50°C	100% / Lot

6*	Verification of Lead Center Position	Using approved fixture		100% / Lot
7~~6~~	Final electrical test	As per defined herein	In accordance tables 8A & 8B	100% / Lot
8~~7~~	Visual Inspection	As specified herein	Paragraph 6.4.13	100% / Lot
9~~8~~*	Mechanical Inspection	As specified herein	Paragraph 6.4.14 for length, width, thickness and concavity measurement	~~* See below~~1% Lot

* ~~Only the length width and thickness will be verified on 1 % of selected lot and 100% pin center position using approved fixtures. Similar fixtures will be used by CEA to expedite the process of inspection and to avoid misunderstanding. Hamamatsu will provide drawings/fixtures (TBR)~~CEA will use similar methods and fixtures for these measurements to avoid discrepancy.

6.4.11.5 DPD Electrical Test

The following two tables 8A & 8B, illustrate the electrical and optical characteristics of the DPDs. The measurement of photosensitivity (electrical) may not be performed by CEA at the same wavelength as Hamamatsu due to test equipment capability. CEA test processes and procedures shall be validated by Hamamatsu prior to flight production.

Table 8A – PIN A (Small diode)

Parameter	Symbol	Condition	Min.	Type	Max.	Unit	Sampling
Photo Sensitivity	S	λ = 540 nm	0.35	0.38	0.41	A/W	100%
Dark Current	I_D	V_R = 70 V	0.2	1.0	3.0	nA	100%
Terminal Capacitance	C_t	V_R = 70 V, f = 1 MHz	12	14	16	pF	100%

Table 8B – PIN B (Large diode)

Parameter	Symbol	Condition	Min.	Type	Max.	Unit	Sampling
Photo Sensitivity	S	λ = 540 nm	0.35	0.38	0.41	A/W	100%
Dark Current	I_D	V_R = 70 V	0.5	2.5	7.5	nA	100%
Terminal Capacitance	C_t	V_R = 70 V, f = 1 MHz	54	63	72	pF	100%

6.4.11.6 DPD Qualification on Fully Assembled and Screened DPDs

DPD qualification shall be in accordance with Table 9 and shall be performed on fully screened

DPD samples as per table 7. After review of technology evaluation data from the first 100 DPD lot (except for 1000 hours steady-state life test) a decision will be made for flight production at the kick-off meeting. Corrective action, if required, will be implemented prior to flight production. At the first delivery lot of 600 assembled and tested DPDs along with 9 blank ceramic substrates as per table 6B and 5 dies as per table 5B, 60 DPDs will be selected and will be tested as specified in table 9 (qualification tests) by CEA All tests specified in table 9 shall be performed by CEA in parallel with the flight production and screening as per table 7 due to a minimum risk and tight schedules. The total time for qualification testing shall not exceed 5 weeks. Flight DPDs will be supplied by Hamamatsu to CEA from screening lot (as per table 7) for qualification. All qualification procedures and flow diagrams shall be available from CEA to Hamamatsu/NRL one month prior to qualification testing for review and approval. A report of all data of qualification tests will be available one month after the receipt of the first sub=lots of DPDs.

Table 9. Lot Acceptance Qualification Test to be performed by CEA on DPDs screened as per table 7

S / N	Test	MIL-STD-883		Quantity
		Method	Condition	
1	Visual Inspection		As per para. 6.4.13	60
2	Acoustic Microscopy			60
3	Electrical Verification	As specified herein	As per table 8A & 8B	60
4	Physical dimensions Solderability Resistance to solvents & fluxes	As per figure 1 ANSI/J-STD-002 2015	As per para. 6.4.14	60 1 3
5	Moisture Intake	JESD-22-A113	168 hrs, +50°C, 50%RH	6 out of lot of 60
6	Electrical Verification after moisture intake testing	As specified herein	As per tables 8A & 8 B	6
7	Acoustic Microscopy on parts tested during step 5			6
8	Visual Inspection of parts tested during step 5. These parts will not be tested again and stored separately	2032	As per para. 6.4.13	6
9	Steady-state life and End-point electricals, as per tables 8A & 8B	1005	1000 hours at 60^{0}C	22 out of lot of 60
10	Thermal cycle	1010	* 60 cycles at -30^{0}C to +50^{0}C at ramp rate not exceed 1°C/minute with ½ hour dwell at each temp.	10 out of lot of 60
11	Electrical verification after thermal cycling step 8	As specified herein	As per table 8A & 8B	10
12	Acoustic Microscopy on parts tested in step 9			10
13	Visual Inspection on parts tested during step 9. These parts will not be tested again and stored separately	2032	As per para 6.4.13	10
14	Radiation Testing	Per para. 7.1	Total Ionizing Dose testing	3 out of lot of 60
15	DPA Perform the following tests on the parts tested in step 5 and step 10 (one from each test device): - Radiography - SEM Analysis - Ceramic Substrate Evaluation - Die Attachment and Wirebond Evaluation (wirebond evaluation may be subjective due to attachment of optical silicone resin to the wirebond)			2

* For reference only: -30°C to +50°C is -10°C and +10°C above operating temperature required for the mission (including ground system). 1°C/minute is 12 times faster than the real requirement of 5°C/hour

6.4.12 Workmanship and Environmental Control

DPDs shall be manufactured, processed, and verified to meet the performance requirements of this document and with the production practices, workmanship instructions, inspection and test procedures, and training aids prepared by Hamamatsu. Detail process flow will be available for review at Hamamatsu during the kick-off meeting. The manufacturing environments should be strictly controlled for temperature, humidity, and contamination at every phase of manufacturing.

6.4.13 Visual Inspection

- Visual Appearance
  - Method: Visual sampling (100%)
  - Criteria (foreign materials that can be wiped off should be excluded)
  - Foreign material and bubble (in active area) – reject: diameter more than 200um.
  - Scratch – reject: hard scratch.
  - Silicone Resin window – reject: Delamination and micro-cracks.
  - Pin – reject: hard scratch on soldered surface due to tools abnormal bending.
- Foreign material that can be wiped off should be acceptable and if so removed before shipping.
- There will be a minimum clearance of 100µm between dies and the ceramic walls.
- Foreign material and bubble (in active area) in the silicone resin window of DPD should be examined under a magnification of 4-10X. Any bubbles greater than or equal to 200µm in diameter should lead to DPD rejection.
- Leads, scratches on gold due to tools, abnormal bending, should be rejected ~~(table 2)~~. Minor scratches on leads are allowed beyond 4mm from ceramic surface.
- No Delamination and micro-cracks allowed.
- No lead rework ~~allowed for verification of pin alignment or for any other operation~~causing damage to ceramic lead interface, cracks to the lead, or tinning is allowed prior to approval from NRL / CEA.
- Lead alignment and bonding of the leads to be verified by using approved fixtures.
- DPD blank substrate leads after tinning shall be examined for clean, smooth, bright tinning finish, excessive solder (including peaks, via holes are not allowed). Due to the use of high temperature lead free solder, some granularity on the surface of the leads is permitted.
- All wirebonds shall be covered by encapsulant.
- Ceramic substrate edges should be clear off encapsulant.

6.4.14 Final Mechanical Inspection After Encapsulation and Testing

As per figure 1 and as specified herein.

CEA~~:~~ will perform thickness / width / length / position / concavity measurement / position of lead measurements using approved fixtures by Hamamatsu. Jig for lead position will be supplied by Hamamatsu to NRL/CEA. Concavity will be measured on 3 units from each assembly sub-lot by laser displacement and data will be recorded and will be provided as part of the data package.

6.4.15 Failure Reporting and Request for Waiver

A failure is defined as the inability of the DPD to perform within the limits of the test requirement specified herein. All such failures shall be reported to NRL/CEA within 24 hours and a nonconformance report documenting the failure and investigation shall be enclosed with the shipment.

6.4.16 Electro-Static Charges Sensitivity

These DPDs do not have any parts or dies that are ESD sensitive to ESD voltages. Hamamatsu has declared these parts non-ESD sensitive and HPK uses antistatic clothing in clean room but does not use wrist straps. Hamamatsu has tested these devices using test conditions of Resistance (R) = 1.5 kohm, C = 100pF, E = ± 1000V and no degredation has been detected in the performance. These tests were performed on S3590-08, etc., which has similar design as S8576-01 and confirmed no degredation. Similar testing will be performed on S8576-01 on technical evaluation DPDs and flight DPDs.

DPDs will be packaged in the conductive material but no special ESD handling will be performed.

7 ENVIRONMENTAL

The following data is for reference only. It specifies the environment to which the DPD will be exposed after assembly with CsI crystals.

7.1 Radiation

Radiation on DPDs will be performed at CEA and shall not show any degradation in performance of tables 8A & 8B after exposure to a total dose of 10K Rad which is 5 times the expected dose of a 5 year mission. Previous test data of the DPD samples suggests that used silicon processes may be acceptable. The radiation data shall be available for review.

7.2 Vibrations (For Information)

Frequency (Hz)	Qualification Level
20	0.01 g^2/Hz
20 – 50	+4.6 dB/octave
50 - 800	0.04 g^2/Hz
800 – 2000	-4.6 dB/octave

2000	0.01 g^2/Hz
Overall	7.4 g_{rms}

7.3 Temperature Conditions during Spaceflight (For Information)

The following table describes the minimum and maximum temperature conditions for DPD during vacuum and atmospheric conditions of spaceflight.

Parameter	Value	Unit	Remark
Reverse Voltage	<100	V	
Instrument Operating Temperature a) operating temp. over the life of the instrument including ground testing b) orbit temperature over the life of the mission	 – 10 up to +30 – 10 up to +30	 °C °C	 Non-condensing Non-condensing
Nonoperating/operating storage or survival in orbit requirement	-20 to +40	°C	FM Parts, Non-condensing

8 DEFINITION OF THE DELIVERABLE

8.1 Dual PIN Photodiode (DPD)

~~4500~~ 4800~~(TBC)~~ DPDs, fully compliant with this specification will be delivered to NRL/CEA.

8.2 Deliverable documentation

All documentation shall be written in English. As far as possible, all the documentation shall be available in electronic format via CD-R along with the shipment. The electronic format shall comply with the following software: Microsoft Word, Excel, PowerPoint, Project, and Adobe Acrobat Reader (.pdf file).

8.3 Delivery description

The following documents will be sent in electronic format along with the shipment.

- Delivery documents shall describe the following:
  - Total quantity of delivered DPD
  - Quantity of containers and reference of their identification
  - Quantity of individual boxes inside each container

- Documents listed hereafter in section 8.4

8.4 Data Requirements

All test data and test programs shall constitute proof that the DPDs conform to the design material, processes, construction, and performance requirements as specified herein. Each requirement shall be verified by the tests as specified.

8.4.1 Test Data Package

All tests performed during screening and testing on protoflight and flight DPDs will have corresponding test data collected by Hamamatsu. End item test data package to be supplied by Hamamatsu is the collection of all pertinent test data taken in support of certifying DPDs for flight. Original end item data package will be retained at Hamamatsu's facility. A copy of ~~this package~~the final test data as per this specification, will be duplicated and sent to NRL/CEA. A test record containing the performance detail information of each test and the step by step procedural execution log will be made and retained for each test performed on each diode.

8.4.2 Certificate of Conformance

Each shipment of DPDs shall include certification by Hamamatsu that the DPDs are in accordance with the requirements of this specification.

8.4.3 Electronic Test Data

A summary of attributes results for the tests and measurements as defined herein will be supplied in electronic format compatible with Microsoft Excel. The name and number of parameters of the data sheet (field of the excel table) will be provided to Hamamatsu by NRL/CEA at the kick-off meeting.

8.5 Monthly production report

A monthly report shall be issued by Hamamatsu and sent to the NRL/CEA. All nonconformances and their resolutions shall also be included in the monthly reports.

9 SHIPPING CONDITIONS

9.1 DPD packaging

DPD shall be packed as defined herein and in dedicated ESD shipping trays to prevent any stress and damage to the optical silicone resin and on the external leads during the transportation and storage. The packaging list DPD packaging shall be included on the shipping container. ~~Each container shall be individually packed inside a "dry pack" with desiccant inside. The S/N of the DPD shall be included on the "dry pack" also.~~ Packaging and labeling of the diodes shall be as defined in Appendix B (to be revised) and as defined herein.

The designer of the container will prevent any damages of the DPD due to

- shock
- humidity
- Cold temperature

One humidity sensor (50% - 90%) shall be included in the moisture proof pack along with the 25G shock sensor, which is placed outside of the container. One temperature sensor covering a range -20°C to + 60°C, shall be included in the container. This detector shall indicate the highest and the lowest temperature reached during the transportation. Specific labels will be provided by CEA to be glued on the container, such as “High Reliability Material” and “To be opened in a clean room, by authorized personnel only”. The shipping container will not be opened between the Hamamatsu factory and the clean rooms of CEA using precaution as specified herein. If the humidity indicator goes above 70%, notify Hamamatsu to resolve the issues and particular sub-lot shall not be used until the resolution is reached.

9.2 Delivery address

The delivery address is the following:

Mr Charles LYRAUD

L’Orme des merisiers /Dapnia/Sap bat 709 Pce 161

CEA Saclay

91191 GIF SUR YVETTE cedex FRANCE

9.3 Transportation means and conditions

The door-to-door transportation system is chosen by Hamamatsu under its full responsibility. Details of shipping and transportation will be discussed during the kick-off meeting at Hamamatsu.

10 PRECAUTIONS FOR HANDLING DPD’S

The following precautions should be taken by Hamamatsu, Hamamatsu’s subcontractor, CEA, and NRL.

10.1 Precautions for Storage after receipt from Hamamatsu

To protect the terminal leads from oxidation and stains, and to prevent the DPDs from absorbing moisture, contamination damage, avoid unpacking the DPDs in uncontrolled environments until they are actually in use. Since these DPDs are packed in a moisture-proof conductive bag, they can be stored for long periods (about 3 months) if they are left in air-conditioned and controlled environment at normal room temperature and moisture (5°C to 30°C, 70% or below).

After removing the moisture-proof ~~film~~conductive bag, the following precautions shall be taken:

- Store the devices in dry atmosphere 0% RH (closet with dry nitrogen for example).
- Store the devices in dehumidified atmosphere (15°C / 40% RH or below to 25°C / 60% RH or below) and use them within 24 hours.

If the devices in the moisture proof film are stored for more than 3 months in normal atmosphere or if after unpacking, they are left for more than 24 hours, they should be re-baked in nitrogen flow to remove moisture.

Even when the devices are packed with the moisture-proof film, avoid exposing them to water leakage, harmful gases, direct sunlight, or temperature rises (e.g., turning off the air conditioner at night).

10.2 Precautions for Handling or Soldering the DPDs

a) Handling the DPDs – Applying external pressure may damage the diodes, therefore the DPD should be handled personnel who are trained in handling these devices.

b) Soldering - Solder the leads at 260°C or less, within 10 seconds. Do not use any fluxes which are highly acid, alkaline, or inorganic because they may cause the leads to be eroded. Use only approved fluxes.

c) DPD Leads – DPD leads shall not be touched with bare hands. Persons handling the DPDs should wear clean lint-free gloves or finger cots. DPD lead dimensions shall meet the performance requirements.

d) CEA will supply the soldering and cleaning procedures for soldering of the wires to the DPDs to Hamamatsu for review and comments.

10.3 Cleaning

a) Only use ethyl alcohol with a clean room lint free swab. Optical silicone resin is a very soft material, so it is necessary to be very careful when cleaning the optical surface. Pressure while cleaning could cause damage to the wirebond and DPD.

b) Cleaning methods - When removing stains and dirt from the surface, use a cotton swab moistened with alcohol and wipe gently, being careful not to cause any damage. Do not use ultrasonic cleaning methods on these DPDs. The use of ultrasonic cleaning methods will void the warranty of Hamamatsu since this process affects the reliability of the diodes.

10.4 Optical Window

Never touch the optical window, because dirt or scratches on the light input window might cause a loss of sensitivity.

If the window needs to be cleaned, use ethyl alcohol and a clean room swab to wipe off the window gently. Do not use any other organic solvents other than ethyl alcohol as they may cause deterioration of the device's silicone resin and may affect the performance.

11 ACCEPTANCE CONDITIONS AT NRL/CEA

11.1 Checklist

Each shipment will be checked by the CEA as per this specification requirement.

a. Visual inspection of the container including shock detection
b. Visual inspection of the internal packaging
c. Delivery detail versus the contractual arrangements
d. Delivery versus the content listed on the packaging list
e. Exportation documentation conformity
f. Electronic media (CD-ROM) and its content
g. DPD recorded parameters versus the acceptance limits
h. Systematic control will be done on: visual inspection will be performed on optical surface for cleanliness, scratches, and concavity.
i. Sampling Control (10% per lot TBC) will be done on: Mechanical as per 6.4.14, and Electrical as per Table 8A and 8B.

11.2 Delivery Acceptance/Refusal

11.2.1 Pre-receiving inspection at CEA

Pre-receiving inspection will be performed at CEA, France. Nonconformity related to step "a" to "g", in section 11.1, will be communicated to Hamamatsu and NRL via email to resolve the issue immediately.

11.2.2 Receiving inspection at CEA

During receiving inspection, after the acceptance tests performed in 11.1, step "h" and "i" (within two weeks of receipt at CEA) any nonconformity related to step "h" and "i" will be lead to refusal of the entire delivery lot and issues will be discussed immediately for corrective action (NRL and Hamamatsu will be informed via email).

12 PRODUCT ASSURANCE

12.1 Processes

A list of qualified processes to be used for the manufacturing of the DPD will be reviewed at Hamamatsu and may include, at a minimum, the following:

- Name of the process
- Specification or procedure
- Brief description of the process
- Name of the subcontractor (if applicable)
- Related materials or components
- Critically of the process and associated risks (FMECA)

The project shall be informed within one week by the manufacturer of any changes made to the list.

12.2 Reliability (TBD)

To calculate the overall reliability of the GLAST LAT instrument, Hamamatsu shall provide the reliability ~~of each diode, and if possible, the probability of failure. This reliability is a number in FITs~~estimate. This will be based on the S5107 and S3905-08 standard devices.

NOTES ADDED/REVISED ON FIGURE 1.

- 4th note should be changed to "The whole leads surface gold shall be removed and tinned by dipping into two solder (Sn96Ag3.5) baths separately at 250-280°C for 2-3 seconds.
- Add note: Lead length from surface of ceramic shall be free of scratches.

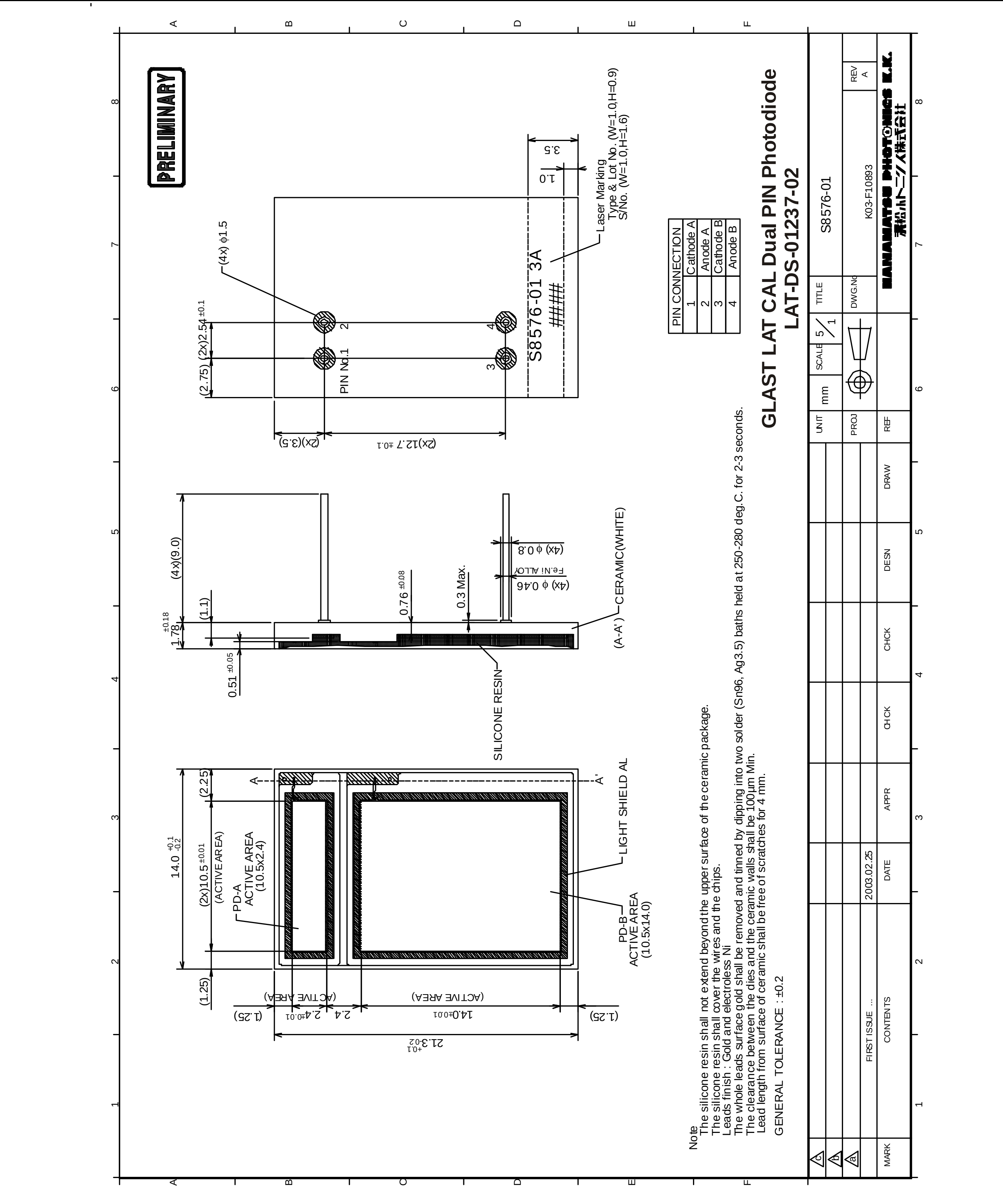


Figure 1. Diagram of the Dual PIN Photodiode Mechanical Specifications

NOTE: This figure will be modified after final agreement from Hamamatsu.

APPENDIX A

HAMAMATSU QA CHECKLIST

NOTE: Hamamatsu's response to the QA checklist was received with comments to Rev 03 of this specification. No additional response to the QA Checklist is required unless the previous response needs to be changed. The checklist is preserved in the specification for completeness of the spec.

HAMAMATSU'S QA ASSESSMENT

1.0 Process Controls

1.1 Quality Management

1.1.1	Does the Hamamatsu's QA have a quality management plan?	Yes ______	No ______	N/A ______
1.1.2	Does the Hamamatsu's QA have support and involvement of management in implementing and maintaining the quality management plan?	Yes ______	No ______	N/A ______
1.1.3	Does the Hamamatsu's QA have a documented and implemented plan to select?	Yes ______	No ______	N/A ______
1.1.4	Does the Hamamatsu's QA review their supplier's (ceramic substrate, silicone resin, die attachment, bondwire, etc.) quality management plan?	Yes ______	No ______	N/A ______
1.1.5	Does the Hamamatsu's QA verify that their supplier's quality management plan has the support and involvement of Hamamatsu's management in implementing and maintaining the plan?	Yes ______	No ______	N/A ______
1.1.6	Does the Hamamatsu's QA verify that communication exists between design, fabrication, test and field regarding performance, quality, reliability, and failure analysis using statistical techniques?	Yes ______	No ______	N/A ______
1.1.7	Does the Hamamatsu's QA determine if quality management plan charters an internal control board or procedure that maintains communication between groups, evaluates data (SPC, reliability, screening, failure analysis, etc.) determines corrective action, and maintains records?	Yes ______	No ______	N/A ______
1.1.8	Does the Hamamatsu's QA have the name of a key contact in the internal control board?	Yes ______	No ______	N/A ______
1.1.9	Does the Hamamatsu's QA verify that the quality plan establishes clear lines of authority and responsibility?	Yes ______	No ______	N/A ______
1.1.10	Does the Hamamatsu's QA verify that the quality plan provides for periodic internal audits?	Yes ______	No ______	N/A ______
1.1.11	Does the Hamamatsu's QA review the quality documentation procedures?	Yes ______	No ______	N/A ______
1.1.12	Has the Hamamatsu's QA completed a self-assessment of their quality management plan?	Yes ______	No ______	N/A ______
1.1.13	Does the Hamamatsu's QA evaluate the self-assessment program?	Yes ______	No ______	N/A ______
1.1.14	Is the Hamamatsu's QA certified for ISO-9001 or equivalent standard?	Yes ______	No ______	N/A ______
1.1.15	Does the Hamamatsu's QA evaluate the preventive maintenance procedure?	Yes ______	No ______	N/A ______

1.2 Statistical Process Control (SPC)

1.2.1	Are the wafer fabrication and assembly lines in continuous, high volume production?	Yes ______	No ______	N/A ______
1.2.2	Does the Hamamatsu's QA have documented and implemented a plan of SPC for wafer and assembly process steps?	Yes ______	No ______	N/A ______

1.2.3 Does the Hamamatsu's QA evaluate the SPC to determine if sufficient control exists for at least the following wafer fabrication steps: Yes ______ No ______ N/A ______

Wafer
EPI Layers
Wafer backside preparation
Masks
Photolithography
Diffusion
Annealing
Oxide deposition/growth
Nitride deposition
Poly etch
Metal etch
Wafer parametric data
Lot acceptance results

1.2.4 Does the Hamamatsu's QA evaluate the supplier's internal / SPC to determine if sufficient control exists for at least the following assembly steps: Yes ______ No ______ N/A ______

Materials
Wafer mount
Wafer saw
Visual
Wirebond
Visual
Electrical test
Mark
Dimensions

1.2.5 Does the Hamamatsu's QA's supplier evaluation criteria recognize the effectiveness of computer automated SPC chart generation. Yes ______ No ______ N/A ______

1.2.6 Does the Hamamatsu's QA request copies of current SPC control charts? Yes ______ No ______ N/A ______

1.2.7 Does the Hamamatsu's QA review the supplier's documented SPC goals and metrics? Yes ______ No ______ N/A ______

1.2.8 Does the Hamamatsu's QA review the supplier's periodic progress reports on SPC goals? Yes ______ No ______ N/A ______

1.2.9 Does the Hamamatsu's QA review the supplier's procedures for determining target values at critical process nodes? Yes ______ No ______ N/A ______

1.2.10 Does the Hamamatsu's QA review the supplier's procedures for responding to deficiencies? Yes ______ No ______ N/A ______

1.2.11 Does the Hamamatsu's QA ensure that the dies are protected and segregated at the wafer level before cutting? Yes ______ No ______ N/A ______

1.3 Continuous Improvement

1.3.1 Does the Hamamatsu's QA verify that the supplier has a documented and implemented plan for continuous improvement? Yes ______ No ______ N/A ______

1.3.2 Does the Hamamatsu's QA verify that a continuous improvement feedback loop exists from test ______ ______ ______ and field operations to design and fabrication regarding yield, performance and reliability? Yes ______ No ______ N/A ______

1.3.3 Does Hamamatsu's QA review the supplier's process/product improvement projects? Yes ______ No ______ N/A ______

1.3.4 Does the Hamamatsu's QA review process/product improvement metrics? Yes ______ No ______ N/A ______

1.3.5 Does the Hamamatsu's QA request data on specific process/product improvements and the resulting feedback from field data? Yes ______ No ______ N/A ______

1.3.6 Does the Hamamatsu's QA's supplier evaluation criteria recognize the effectiveness Design of Experiments (DOE)? Yes ______ No ______ N/A ______

1.3.7 Does the Hamamatsu's QA have expertise to review and evaluate the supplier's use of wafer fabrication and assembly of PIN photodiodes yield models? Yes ______ No ______ N/A ______

1.4 PIN Photodiode Development

1.4.1 Does the Hamamatsu's QA review the supplier's use of proven design rules and standard cells that incorporate process variation statistics? Yes ______ No ______ N/A ______

1.4.2 Does the Hamamatsu's QA review the supplier's methodology of incorporating reliability data from testing, production and field into design rules? Yes ______ No ______ N/A ______

1.4.3 Does the Hamamatsu's QA determine if it is supplier (ceramic substrate, silicone resin, die attachment, wirebond, etc.) policy to qualify all new parts through reliability testing? Yes ______ No ______ N/A ______

1.4.4 Does the Hamamatsu's QA have an acceptable procedure to qualify industrial grade ceramic substrate and assembly? In particular, regarding the following: Yes ______ No ______ N/A ______

Does the supplier produce equivalent MIL part?
Is industrial grade part fabricated on same wafer fabrication line as MIL part?
Is industrial grade part assembled on same line as MIL part?
Verify that industrial grade part is not a downgraded MIL part.
Pre-cap visual performed on 100% parts?
Final electrical tests performed at -30°C, room temp., and +60°C or better?
High temperature operating life
Temperature cycling
Vibration
Acceleration
ESD sensitivity
Solvent resistance
Bond strength
Die shear
Solderability
Lead integrity
External visual on 100% parts?

1.5 Quality Control

1.5.1 Does the Hamamatsu's QA have an acceptable procedure to screen PIN photodiodes? In particular regarding: Yes ______ No ______ N/A ______

Pre burn-in electrical
Burn-in
Final electrical
External visual

1.5.2	If the Hamamatsu's QA allows the deletion of a qualification or screening step listed above, does the Hamamatsu's QA have sufficient test data to justify omitting the step?	Yes ______	No ______	N/A ______
1.5.3	Does the Hamamatsu's QA obtain copies of the supplier qualification test data for new parts (i.e., ceramic substrate, etc.)?	Yes ______	No ______	N/A ______
1.5.4	Does the Hamamatsu's QA re-qualify a part when processes or materials are changed?	Yes ______	No ______	N/A ______
1.5.5	Does the Hamamatsu's QA have sufficient expertise to review and evaluate the supplier's failure analysis on failed parts to determine the physics of failure?	Yes ______	No ______	N/A ______
1.5.6	Does the Hamamatsu's QA review the supplier's corrective action plan to correct defects or out of control processes?	Yes ______	No ______	N/A ______
1.5.7	Does the Hamamatsu's QA review the supplier's change control program for designs, processes, and materials?	Yes ______	No ______	N/A ______
1.5.8	Does the Hamamatsu's QA receive notification when changes to designs, processes or materials occur?	Yes ______	No ______	N/A ______
1.5.9	Does the Hamamatsu's QA receive notification when problems with parts are identified and subsequently resolved?	Yes ______	No ______	N/A ______
1.5.10	Does the Hamamatsu's QA require the supplier to have a quality monitoring program that periodically performs reliability tests on samples taken from the production lines?	Yes ______	No ______	N/A ______
1.5.11	Does Hamamatsu's QA receive copies of the periodic quality monitor reports?	Yes ______	No ______	N/A ______
1.5.12	Does Hamamatsu's QA use industry standard packages?	Yes ______	No ______	N/A ______

2.0 Assembly Process Controls

2.1 Quality Management Plan

2.1.1	Does Hamamatsu have a documented and implemented quality management plan?	Yes ______	No ______	N/A ______
2.1.2	Does Hamamatsu have support and involvement of management in implementing and maintaining the quality management plan?	Yes ______	No ______	N/A ______
2.1.3	Does the quality management plan require communication between design, fabrication, test and field regarding performance, quality, reliability, and failure analysis using statistical techniques?	Yes ______	No ______	N/A ______
2.1.4	Does the quality management plan charter an internal control board (i.e. similar to a review board) that maintains communication between groups, evaluates data (SPC, reliability, screening, failure analysis, etc.) determines corrective action, and maintains records?	Yes ______	No ______	N/A ______
2.1.5	Does the Hamamatsu's QA have the name of a key contact in the internal control board?	Yes ______	No ______	N/A ______
2.1.6	Does the quality plan establish clear lines of authority and responsibility?	Yes ______	No ______	N/A ______
2.1.7	Does the quality plan provide for periodic internal audits?	Yes ______	No ______	N/A ______
2.1.8	Does the quality plan require documentation of audits and follow-up actions?	Yes ______	No ______	N/A ______

2.1.9 Are the results of the self-assessment of the quality management plan available for review? Yes ______ No ______ N/A ______

2.1.10 Does Hamamatsu have an effective preventive maintenance procedure? Yes ______ No ______ N/A ______

2.1.11 Does Hamamatsu have sufficient SPC control for at least the following assembly steps: Yes ______ No ______ N/A ______

Materials
Wafer mount
Wafer saw
Visual
Die attach
Wirebond
Die optical silicone resin encapsulation
Visual
Electrical test
Marking
Dimensions

2.1.12 Is Hamamatsu willing to provide copies of current SPC control charts? Yes ______ No ______ N/A ______

2.1.13 Does Hamamatsu have documented SPC goals and metrics? Yes ______ No ______ N/A ______

2.1.14 Does Hamamatsu have periodic progress reports on SPC goals? Yes ______ No ______ N/A ______

2.1.15 Does Hamamatsu have documented procedures for determining target values at critical process nodes? Yes ______ No ______ N/A ______

2.1.16 Does Hamamatsu have a documented procedure for responding to deficiencies? Yes ______ No ______ N/A ______

3.0 DPD Part Qualification

3.1 Selection Criteria

3.1.1 Were proven design rules or standard cells used for the design of the DPD? Yes ______ No ______ N/A ______

3.1.2 Was reliability data from testing, production and filed incorporated into design rules or standard cells for this part? Yes ______ No ______ N/A ______

3.1.3 Did Hamamatsu exercise sufficient design control, verification, prototyping and qualification for the part? Yes ______ No ______ N/A ______

3.1.4 Did Hamamatsu include the full operating temperature range in the part design? Yes ______ No ______ N/A ______

3.1.5 Has material compatibility been addressed in part design? In particular, regarding dissimilar metals used in wire bonding, die attachment, and optical silicone resin encapsulant? Yes ______ No ______ N/A ______

3.1.6 Are cleaning materials compatible with part materials, both internal and external? In particular, will cleaning materials corrode part materials? Have long term effects been considered? Yes ______ No ______ N/A ______

3.1.7 Were coefficients of thermal expansion considered when designing and processing parts? Yes ______ No ______ N/A ______

3.1.8 Are there any potential areas where part reliability may be effected during environmental stress testing due to mismatches in coefficients of thermal expansion? Yes ______ No ______ N/A ______

3.1.9 Does the next level assembly require performance of the part that is near the specification limits or is there sufficient margin? Yes ______ No ______ N/A ______

3.4.1.10	Did the Hamamatsu's QA follow the supplier selection criteria described in the Hamamatsu's QA's parts management plan?	Yes ______	No ______	N/A ______
3.4.1.11	Did the Hamamatsu's QA follow the part selection criteria described in the Hamamatsu's QA's parts management plan?	Yes ______	No ______	N/A ______
3.4.1.12	Does the Hamamatsu's QA's evaluation of part qualification and screening data follow the documented procedures in the Hamamatsu's QA's parts management plan?	Yes ______	No ______	N/A ______

3.2 Manufacturing

3.2.1	Is the DPD a high volume, continuous production part?	Yes ______	No ______	N/A ______
3.2.2	Does Hamamatsu use statistical techniques to establish, control and verify fabrication and assembly processes and performance characteristics?	Yes ______	No ______	N/A ______
3.2.3	Are processes and equipment used to fabricate and assemble the part common to a family of DPDs?	Yes ______	No ______	N/A ______
3.2.4	Does Hamamatsu provide adequate assurance that the part will be available for both the short and long term? If not, is there an acceptable obsolescence plan?	Yes ______	No ______	N/A ______
3.2.5	Does Hamamatsu have documented procedures to inspect and control materials used to fabricate the part?	Yes ______	No ______	N/A ______
3.2.6	Does Hamamatsu have documented process instructions, lot travelers, and SPC control points for DPD part assembly? In particular, is there sufficient control for at least the following steps: Electrical test High temperature operating life Thermal cycling Bond pull Solderability Lead integrity	Yes ______	No ______	N/A ______
3.2.7	Does Hamamatsu have internal test specification that adequately test the performance characteristics of the part?	Yes ______	No ______	N/A ______
3.2.8	Does Hamamatsu have a sufficient control in place to assure that no parts are shipped until all specified tests are complete?	Yes ______	No ______	N/A ______
3.2.9	Are tests systems and software of sufficient accuracy and precision to perform the specified tests?	Yes ______	No ______	N/A ______
3.2.10	Does Hamamatsu have sufficient maintenance, calibration, and repair procedures to maintain the required accuracy and precision of the test systems?	Yes ______	No ______	N/A ______

3.3 Reliability

3.3.1	Does Hamamatsu have sufficient data, both accelerated test data and field data, to support the reliability claims?	Yes ______	No ______	N/A ______
3.3.2	Does Hamamatsu correlate accelerated test data with filed data?	Yes ______	No ______	N/A ______
3.3.3	Does Hamamatsu destructively analyze failed parts to determine the failure mechanism?	Yes ______	No ______	N/A ______

3.3.4	Does Hamamatsu have a good understanding of the physics of failure for each of the failure mechanisms in the part?	Yes ______	No ______	N/A ______
3.3.5	Does Hamamatsu have sufficient enough understanding of the physics and the statistical methods of accelerated reliability tests to determine the realistic failure rates?	Yes ______	No ______	N/A ______
3.3.6	Does Hamamatsu have data on long term dormant storage of the DPD?	Yes ______	No ______	N/A ______
3.3.7	Does Hamamatsu have data on infant mortality rates for the DPD?	Yes ______	No ______	N/A ______

4.0 Handling and Shipping

4.1 Handling

4.1.1	Are Hamamatsu's handling procedures and storage areas sufficient to prevent damage or deterioration?	Yes ______	No ______	N/A ______
4.1.2	What is the moisture sensitivity level of the DPD?	Yes ______	No ______	N/A ______
4.1.3	Does Hamamatsu have recommended procedures for storing and handling of the part to avoid moisture-induced stress during soldering and bonding?	Yes ______	No ______	N/A ______
4.1.4	Do Hamamatsu's part handling procedures and areas prevent damage or deterioration to the part?	Yes ______	No ______	N/A ______

4.2 Shipping

4.2.1	Are parts shipped in containers to prevent moisture absorption and ESD damage?	Yes ______	No ______	N/A ______
4.2.2	If parts are moisture sensitive, are parts shipped with a moisture indicator?	Yes ______	No ______	N/A ______

APPENDIX B

PACKAGE SPECIFICATIONS

To be revised

HAMAMATSU

HAMAMATSU PHOTONICS K.K.

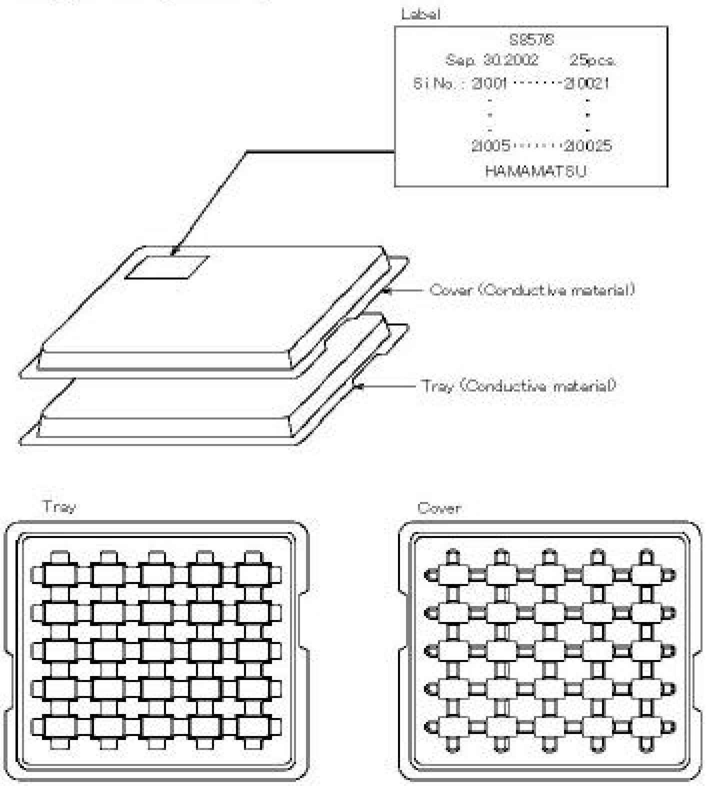
(P.6 / 9)

Type No.	ITEM	REVISIONS	DATE	APPROVED
S8576	a		. .	
	b		. .	
DWG No.	c		. .	
	d		. .	
KQC-B14514	e		. .	

7.Packing specifications

7.1 Inside packing

- A-PET Tray (Max.25 pcs / case)



FormKXX-25-6 A

HAMAMATSU

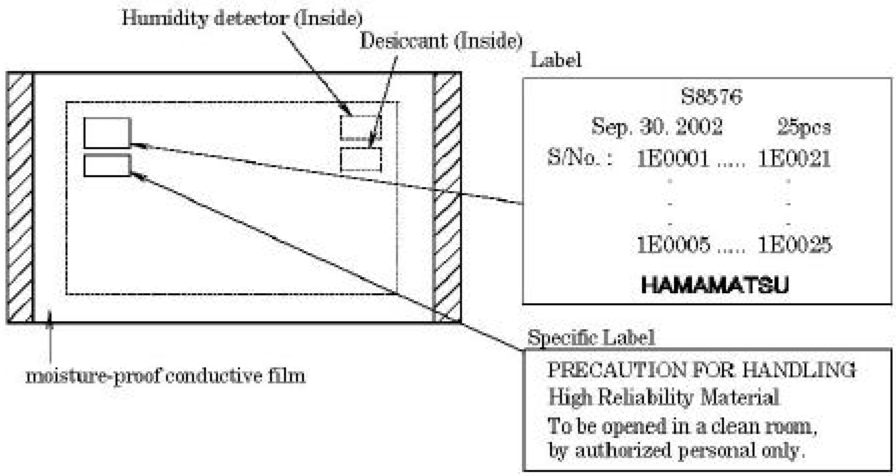
HAMAMATSU PHOTONICS K.K.

(P. 7 / 9)

Type No.	ITEM	REVISIONS	DATE	APPROVED
S8576	a		. .	
	b		. .	
DWG No.	c		. .	
KQC-B14514	d		. .	
	e		. .	

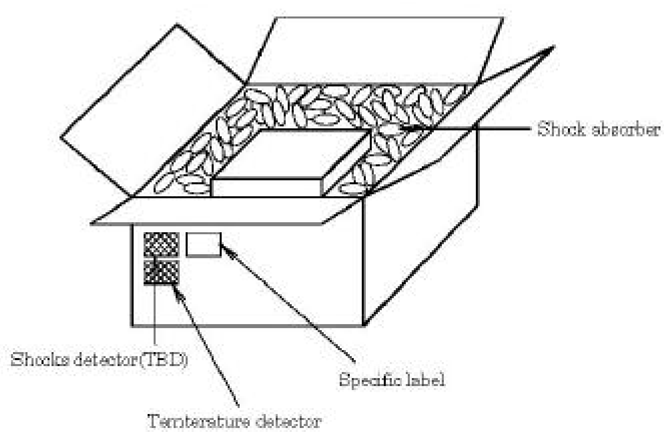
7.2 Moisture-proof pack

- One humidity detector shall be included in the pack.



7.3 Outside Packing

- The devices are packed in a corrugated paper box for delivery.
- Shocks detectors shall be glued on each corrugated paper box.
- One temperature detector shall be glued on each corrugated paper box.
- Specific labels shall be glued on each corrugated paper box.



FormKXX-26-6 A